Estimation of Natural Biodegradation Rates of Organics in Buried Waste at INEEL

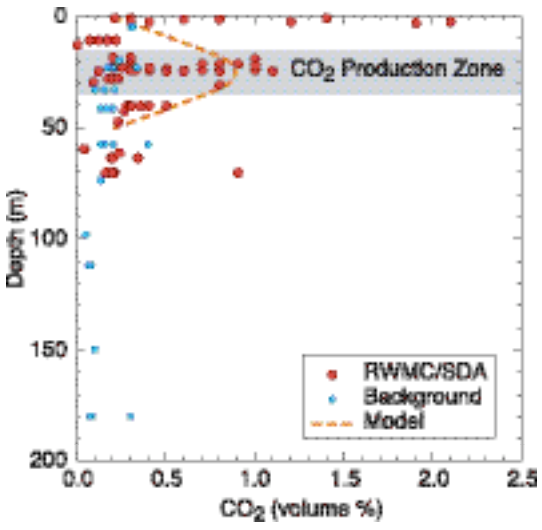
Mark Conrad and Donald J. DePaolo
Contact: Mark Conrad, 510/486-6141, msconrad@lbl.gov

RESEARCH OBJECTIVES

Radioactive waste resulting from U.S. Department of Energy activities is buried in shallow pits in the Subsurface Disposal Area (SDA) at the Radioactive Waste Management Complex (RWMC) of the Idaho National Engineering and Environmental Laboratory (INEEL). In addition to the radionuclides, the waste drums also contain significant amounts of chlorinated solvents mixed with lubricating oils. Leakage from the drums has resulted in a plume of vapor-phase contaminants in the vadose zone. The main objective of this study was to use measurement concentrations and isotopic compositions of CO_2 from the SDA to assess the potential for bioremediation of the organic contaminants at the site.

APPROACH

Over a 2-year period, pore gas samples were collected from monitoring wells in and around the RWMC site. Gas sampling ports within the monitoring wells were designed for sampling discrete depth intervals. Sampling depths ranged from <1 m to 180 m. For each sample, the CO_2 concentration and stable carbon isotope ratios ($\delta^{13}C$ values) were measured. In addition, the ^{14}C contents of a subset of these samples were also measured.



Fgure 1. Concentrations of CO_2 versus sampling depth for samples from monitoring wells in the Subsurface Disposal Area (red circles) and from background wells (blue circles) adjacent to the site. The dashed orange line corresponds to CO_2 concentrations calculated for a 20 m thick production zone (the shaded area between 15 m and 35 m) with CO_2 concentrations averaging 0.9% (versus 0.2% in the background wells).

ACCOMPLISHMENTS

Carbon dioxide concentrations in pore gas samples from monitoring wells in the vicinity of the disposal pits were 3 to 5 times higher than the concentrations in nearby background wells. The $\delta^{13}C$ values of CO_2 from the disposal pits averaged 2.4‰ less than CO_2 from the background wells, indicating that the elevated CO_2 concentrations around the pits were derived from source materials with $\delta^{13}C$ values in the range of -24‰ to -29‰. These $\delta^{13}C$ values are typical of lubricating oils, but higher than most solvents. The radiocarbon (^{14}C) contents of CO_2 across most of the site were significantly elevated above modern concentrations because of reactor blocks buried in a subsurface vault at the site. However, several samples collected from the high-CO_2 zone on the far side of the RWMC from the reactor blocks had very low ^{14}C contents (less than 0.13 times modern), confirming production from lubricating oils manufactured from fossil hydrocarbons.

SIGNIFICANCE OF FINDINGS

The key aspects of the data collected for this project include the following:

- The higher concentrations of CO_2 in the pore gas samples from the vicinity of the disposal pits indicate elevated levels of subsurface microbial activity.
- The lower $\delta^{13}C$ values of the CO_2 in the disposal area suggest that the source of the elevated CO_2 concentrations is organic carbon.
- ^{14}C contents of less than 13% of modern indicate that biodegradation of fossil hydrocarbon compounds in the waste material is the primary source of the CO_2.

A simple 1-dimensional production-diffusion model of the CO_2 anomaly observed at the site is consistent with intrinsic biodegradation rates on the order of 0.5 to 2.0 metric tons of carbon per year. This represents degradation of approximately 1% per year of the lubricating oils buried in the disposal pits.

RELATED PUBLICATION

Conrad, M.E., and D.J. DePaolo, Carbon isotopic evidence for biodegradation of organic contaminants in the shallow vadose zone of the Radioactive Waste Management Complex. The Vadose Zone Journal, 2003 (in press).

ACKNOWLEDGMENTS

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